Assessing Blue Carbon Stock in Delaware's Tidal Marshes

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Abstract

Coastal wetlands offer numerous ecosystem services, including the ability to trap and store carbon and are today increasingly susceptible to human and climate-related stressors. Consequently, interest has expanded in tidal wetland potential to help offset carbon emissions through sequestration and vertical sediment accretion collectively referred to as "blue carbon". There is an ongoing need to quantify the accumulation and standing stock of carbon within these systems and to assess how environmental gradients, especially salinity, affect the variability of stocks within marshes of an intrastate region. This question was investigated through collection of sediment cores covering a salinity gradient of 0-35 ppt across the two sites comprising the Delaware National Estuarine Research Reserve. Cores were segmented into halves, dried at 105^{0}C for 24 hours and homogenized. Bulk carbon was measured in triplicate using loss on ignition, the methodology of which was also tested to determine ideal time and temperature parameters. Results suggest that organic carbon density varies spatially and may possess a strong negative correlation with bulk density while the role of salinity remains uncertain. This work improves existing knowledge of Delaware-specific carbon stocks and sheds additional light on the use of environmental proxies for carbon storage extrapolation over un-sampled areas, further informing scientists, policymakers, and land-managers on the manifold benefits of tidal wetlands in the context of restoration and greenhouse gas sequestration potential. Determination of carbon stock and accumulation rates in Delaware marshes adds to the growing understanding of the role of such wetlands across North America and their prospective carbon storage characteristics.

Background

"Blue carbon" is the component of carbon that is trapped in coastal and marine ecosystems, typically in the form of accreted biomass. These coastal habitats in which it is stored typically fall into one of three primary categories: marshes, mangroves, and seagrass beds/SAV. While their spatial scope extends around the world to every continent except Antarctica (Figure 1), these ecosystems are rapidly disappearing, which bodes poorly for any hope of negating the worst effects of climate change. Additionally, blue carbon systems play a major role in the carbon cycle, storing carbon at rates that are over 10x faster than the world's forests (Mcleod et al. 2011). Numerous studies have concluded that despite occupying only about 0.2% of the ocean surface, vegetated blue carbon habitats possess roughly 50% of the carbon stored in marine sediments worldwide (Donato et al. 2011, Duarte et al. 2013, Mcleod et al. 2011, Nelleman et al. 2009).

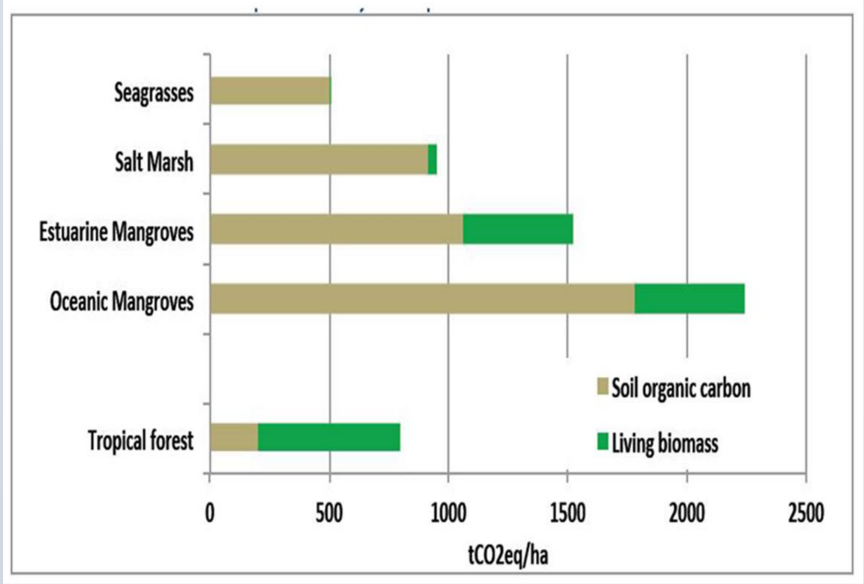


Figure 1: *global carbon sinks;* Murray et al. 2011

As such, understanding blue carbon stock at a regional level has key implications. Among these are climate adaptation, economic valuation of wetland services, and general indication of marsh health. The key takeaway is that by using the economic leverage of these systems to directly benefit them through restoration and preservation , they will play an important role in mitigating a warming climate.

Methods & Materials

This study was conducted at the two sites that comprise the Delaware National Estuarine Research Reserve.

- Blackbird Creek - oligohaline system with a salinity range of 0-5 ppt,
- St. Jones Reserve - meso-polyhaline marsh with a broad salinity range of 7-35 ppt.

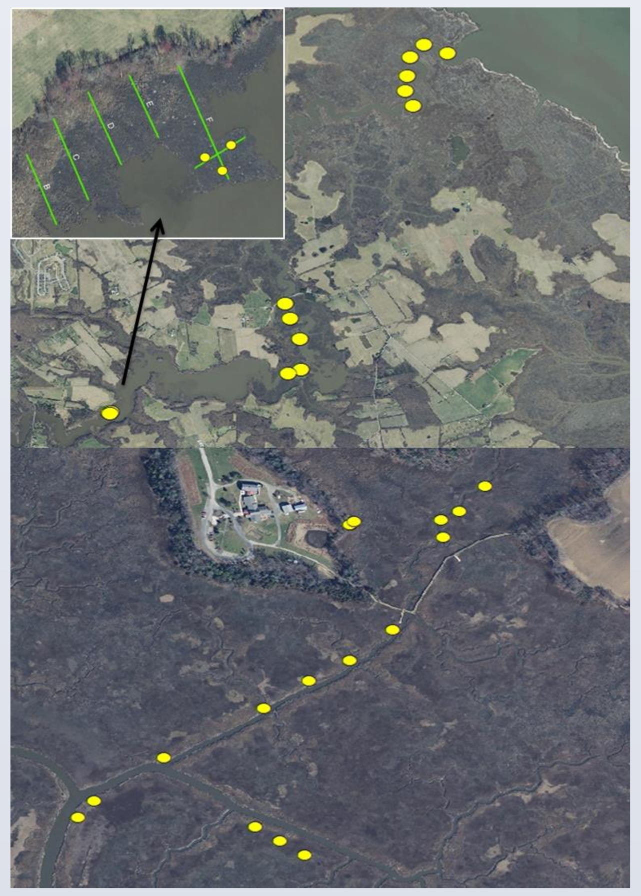


Figure 2: *Sample plots for Blackbird Creek (top) and St. Jones Reserve (bottom)*

- 31 soil cores collected from across the two sites (Figure 2) using 5 cm diameter plastic core tubes. Cores refrigerated for at least 24 hours prior to processing
- Each core photographed, corrected for compaction, and segmented into halves from which triplicates were taken.
- Samples—186 in all—homogenized, dried at 105^{0}C for 24 hours, and measured for dry bulk density.
- 1.0-3.0 g of sediment per sample placed in a muffle oven at 550^{0}C for 4 hours

- Experimentally determined prior to experiment (Figure 3).
- All samples weighed prior to and following ignition to measure percent of mass lost
  - Organic matter %
- Commission for Environmental Cooperation study (2015) used to derive percent organic carbon
- Bulk density data used to further expand percent organic C loss to define sediment carbon density (gC/cm^3)

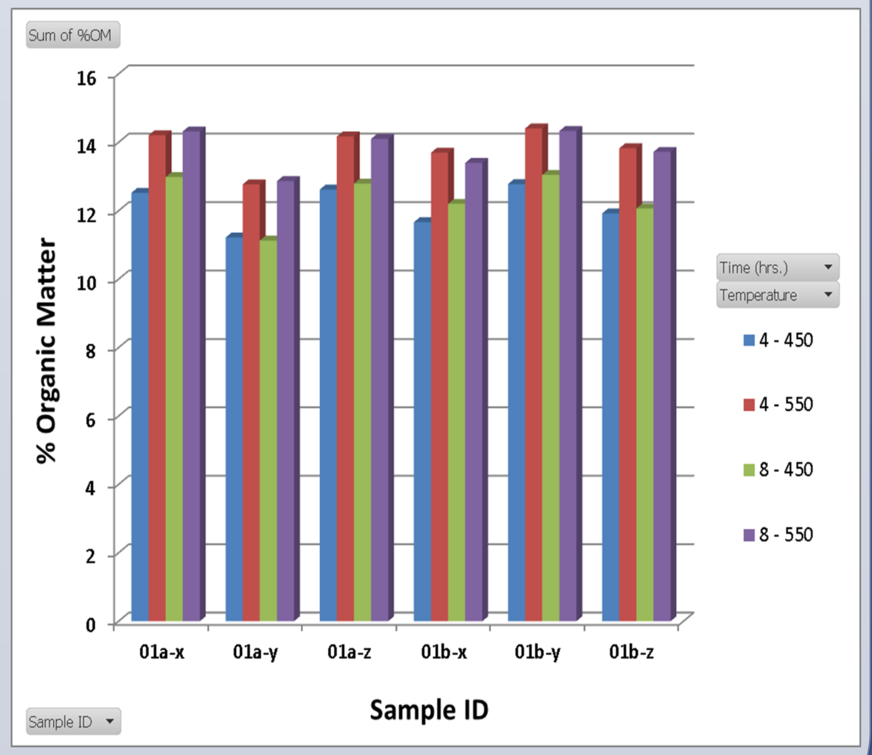


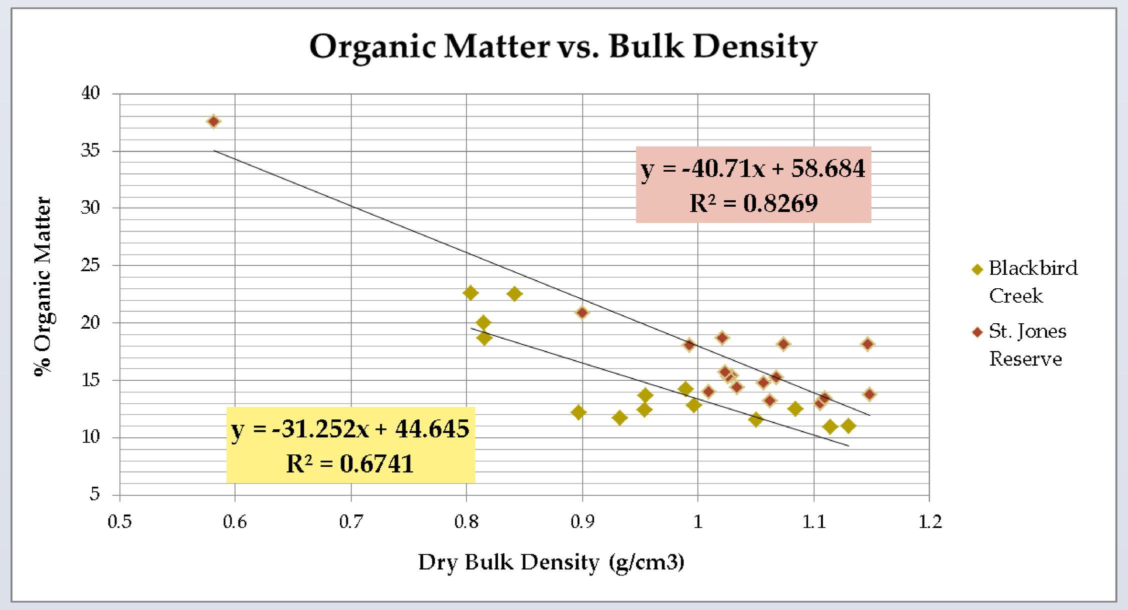
Figure 3: *Results of LOI methodology experiment*

Results

- Mean organic matter percentage similar for both sites despite considerable variation in salinity range
- No significant difference found between the sites with regard to %OM (Figure 4) and, thus, percent organic carbon.
- Percent organic matter found to possess strong negative correlation with dry bulk density (Figure 5) while relation to salinity fairly weak.

t-Test: Two-Sample Assuming Unequal Variances		
	SJR Avg. %OM	*BB Avg. %OM*
Mean	17.04147542	14.77760039
Variance	33.09579112	18.21203533
Observations	17	14
df	29	
t Stat	1.256222136	
P(T<=t) one-tail	0.109530766	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	**0.219061533**	
t Critical two-tail	2.045229642	

Figure 4 (Above): *Descriptive stats for two sites*
Figure 5 (Below): *Negative correlation trend for %OM and bulk density*



- At salinities below 15 ppt., %OM is shown to be highly variable, ranging from roughly 8-43%. However, above 15 ppt., %OM holds fairly constant between 10-20% (Figure 6)
  - Suggests that oligohaline systems may have potential to store greater amounts of carbon regionally
  - Other factors at play (e.g. bulk density, microbial activity, and vertical/lateral carbon gas flux).

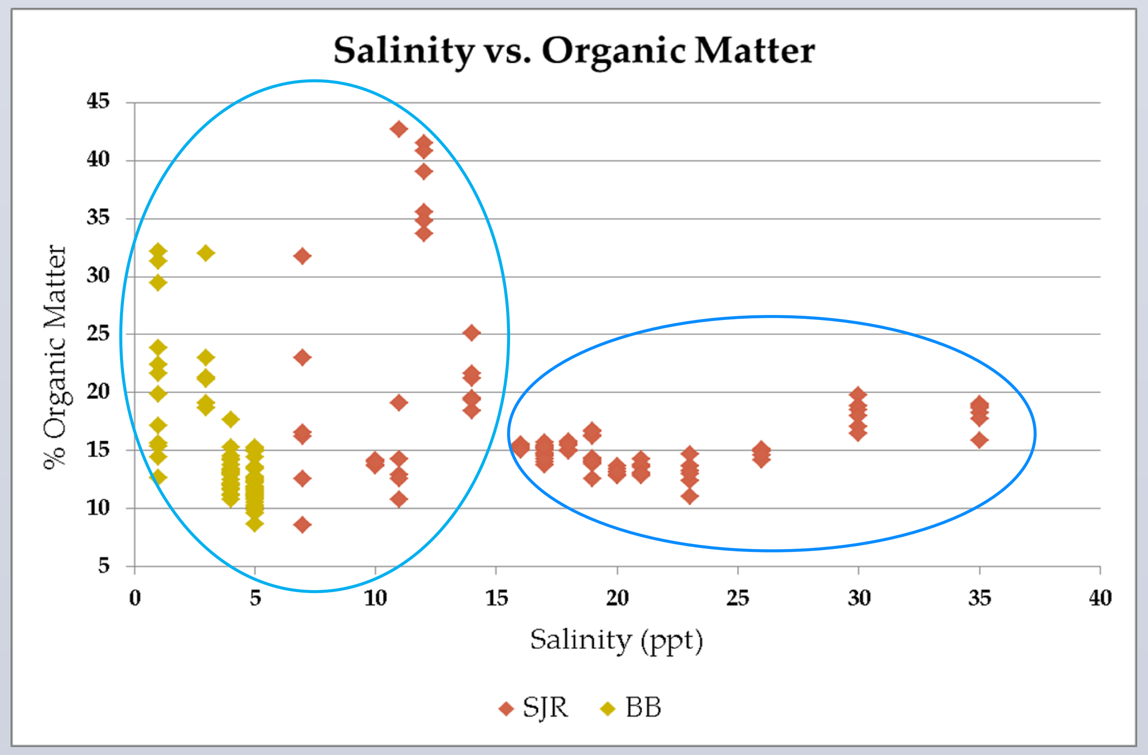


Figure 6: *An interesting trend in %OM above & below a 15 ppt salinity threshold*

Conclusions

The intent of this research experiment was to assess whether and to what extent salinity plays a role in soil carbon storage within blue carbon habitats, specifically in the tidal marshes of the two sites comprising Delaware's National Estuarine Research Reserve. This goal falls in line with expanding scientific and regional planning efforts to mitigate greenhouse gas emissions and to evaluate the economic potential of coastal ecosystem services in the United States and abroad. Using Loss on Ignition (LOI) methodology, soil cores were assessed for percent organic matter content, which was expanded to define percent organic carbon as well. Carbon data were graphed against salinity estimates from each site along with dry bulk density measurements taken in the lab. Scatterplots reveal a strong negative correlation between dry bulk density and carbon content whereas salinity possessed a weaker, less definitive correlation with carbon stock. Percent organic matter was revealed to be far more variable at salinities below 15 ppt., however, while remaining fairly consistent at levels higher than 15 ppt. No significant difference was found between overall organic matter levels between the two sites of the DNERR despite their variation in salinity range. The results of this study lend some merit to preexisting evidence that suggests more saline systems store less blue carbon. Additionally, there are numerous factors that deserve future consideration, including carbon storage along a vertical soil gradient, the role of soil gas flux, and the degree of microbial activity at various pore-water salinities.

Understanding how carbon storage varies by habitat at a regional scale will eventually enable coastal managers and policymakers to prioritize conservation needs and to utilize easy-to-measure environmental variables (e.g. salinity and bulk density) to estimate carbon stock across a diverse landscape.

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